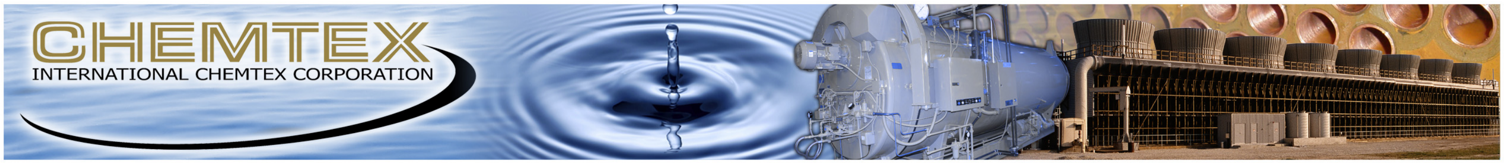

WATER TREATMENT NEWS

Do You Know Where Your Boiler Fuel Dollars Are Going?

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Steam boilers cost a lot of money to operate. Labor, including operator salaries, maintenance and repair costs, water and sewer, electricity, chemicals, ancillary equipment and depreciation all add up. But the 800-pound gorilla of boiler operating costs is fuel. Consider the following example:

- 500 HP boiler, operating at 100 psig
- 50% average load; 340 days per year operation
- Steam generated:
  207,000 lb/day
  70,380,000 lb/year

At 85% combustion efficiency and 80% overall efficiency, this boiler will consume 307.8 thousand cubic feet (mcf) of natural gas per day. At $9.00 per mcf, that equates to $2770/day, or $942,000/year! And 85% combustion efficiency means that the burner on this boiler is well-tuned. Many boilers operate far less efficiently than this, some as low as 60% overall efficiency, which significantly increases the fuel consumption. The fuel bill for even a moderately sized boiler can be in the millions of dollars per year.

As these numbers suggest, boiler fuel consumption represents a major portion of the overall operating cost of the typical manufacturing or commercial/institutional facility. As fuel prices increase, it is increasingly important for facilities engineers to be able to identify areas of energy loss in their boiler systems and quantify the losses. Armed with this information, the engineer can make informed decisions regarding the best expenditures of time and money to recoup energy losses and help balance his budget.

But therein, as the bard said, lies the rub – while identifying the areas of energy loss from a boiler system is relatively easy, quantifying the losses accurately is difficult. And without knowing how many fuel dollars his system is losing in a particular area, it is impossible for a facility manager to determine if money spent on making a change to reduce the loss will be recovered in the savings.

So what does an engineer or facility manager do to assure his boiler system is operating as efficiently as possible? The first step is to identify the areas of energy loss from his system. Most industry analyses of "boiler efficiency" focus on only two areas of energy loss from the boiler – flue gas or stack losses and radiation/convection losses. Radiation and convection losses are basically a constant based on steam generating capacity and operating pressure. Stack losses vary based on burner efficiency and boiler heat transfer efficiency. Analyses that consider only these two areas of boiler energy loss are actually dealing specifically with boiler combustion efficiency.

Combustion efficiency is a measure of how effectively the boiler converts the energy potential in the fuel it burns into usable heat in the form of steam. Combustion efficiency measurements are extremely important, but they do not address two other sources of energy loss from a boiler system – blowdown losses and unreturned condensate losses. A more comprehensive analysis of energy usage in a boiler system includes these areas of loss as well.

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Let's look at the four areas of energy loss from a boiler system. Heat that leaves the boiler in the flue gas represents the largest single energy loss from most boiler systems. This "stack loss" results from three factors – unburned fuel, excess air and incomplete transfer of heat from the combustion chamber through the boiler tubes into the water. Unburned fuel in the flue gas exists when insufficient air is provided to the burner to drive the combustion process to completion. Incomplete combustion not only wastes fuel, it also causes soot to deposit on fireside surfaces, further reducing efficiency by impairing heat transfer through the boiler metal. Further, it creates a dangerous condition by producing poisonous carbon monoxide (CO) gas.

To prevent unburned fuel and the production of soot and CO, combustion air in excess of that required to completely burn the fuel is provided to the burner. Too much excess air, however, increases the amount of energy lost up the stack. All of the excess air supplied to the burner must be heated up to combustion temperature. The more excess air supplied, the more fuel is required to heat it. The ideal air-to-fuel mix to assure complete combustion while minimizing excess air energy loss results in about 15% excess air, or 3% excess oxygen (O_2) in the flue gas. These conditions provide the best combination of safety and combustion efficiency attainable.

A qualified burner technician can tune the burner to operate in this manner. Depending on burner age and condition, and boiler load and operating pressure, tune-ups should be done at least annually, in some cases more frequently. Tuning the burner can provide real savings – reducing stack gas excess O_2 from 6% to 3%, for example, provides a 1-2% reduction in heat loss. In the boiler system described in the earlier example, this would amount to a savings of nearly $10,000/year. As a burner tune-up would typically cost about $750-$1000, this represents an excellent return on investment.

The other aspect of stack losses involves incomplete heat transfer through the boiler tubes. Boiler heat transfer is affected by soot and other deposits on the fireside, and by scale and sludge deposits on the waterside. These deposits act as insulation, preventing heat from transferring to the boiler water, diverting it instead up the stack. Scale as thin as $^1/_{16}$" can decrease boiler efficiency and increase fuel use by 10%. Pound for pound, soot is even more insulating than most scale – in the boiler system described earlier, energy lost due to scale or soot can be $94,000/year or more. Cleaning the waterside and/or fireside surfaces can obviously be a well-placed investment.

Blowdown is an important aspect of boiler system operation. Surface blowdown serves to control boiler water cycles of concentration and help provide the proper water chemistry necessary to control scale, corrosion and the production of dry steam. Bottom blowdown removes accumulated sludge, preventing it from building up and forming scale. While blowdown is critical to safe and efficient boiler operation, it does serve as a conduit for energy loss from the system.

Every pound (pint) of boiler water blown down from a boiler operating at 100 psig carries with it 309 BTUs of heat. Again from the earlier example, if the boiler were operated at 10 feedwater cycles of concentration, total blowdown would be 23,000 lb of water per day, with a heat content of 7.1 million BTUs. This amounts to $64/day, or over $21,700/year going down the drain.

Some of this energy could be recovered by installing a blowdown heat exchanger, in which boiler make-up water is heated by the blowdown. This option would have a cost associated with it, which would be recouped over time.

Another option for reducing blowdown losses could be to reduce the blowdown rate itself by increasing boiler water cycles of concentration. How far cycles of concentration could be increased would depend on feedwater chemistry, but this option may not involve a cost at all, only an adjustment in control parameters. If the plant does not have an automatic blowdown controller, it may be recommended to install one when increasing cycles of concentration to provide more precise boiler water chemistry control. The return on investment would depend on the cost of the controller and how far cycles could be increased. Again from the earlier example, if cycles of concentration could be increased to 20, blowdown would be reduced to 10,895 lb/day, a savings of over 12,000 lb/day. The energy savings as result of this change would be 4.68 mcf/day, a savings in fuel cost of $42 per day, or over $14,000/year. Additional savings would also accrue as a result of this change, as over 490,000 gallons of water would be saved, as well as the chemicals necessary to treat this water. Water and chemical savings could amount to well over $2,000 annually.

When steam does its work, whether that is driving a piece of machinery or heating a process, product or space, it gives up its latent heat of vaporization and condenses back into liquid water referred to as condensate. In most systems, some or most of the condensate is collected and returned to the boiler room, where it is reused by the boiler to make more steam. Reusing condensate in this manner is desirable for several reasons. It reduces make-up water consumption, and, being low in dissolved solids content, is high quality water for making steam. Most important, however, is the fact that condensate is a source of energy input to the boiler system. If, for example, the temperature of the condensate is 175°F when it is returned to the boiler room, it represents an energy input to the system of 115 BTUs per pound, based on replacing, pound for pound, make-up water at 60°F. Fuel requirements are reduced by the amount of heat energy recovered in the returned condensate.

In some systems, some or all of the steam produced is used directly in the process, and no condensate is available to return to the boiler. More often, however, most or all of the steam is condensed and is potentially available for return to the boiler room. Frequently, not all the available condensate is returned to the boiler room, for varying reasons. Return piping may not be in place, or maybe engineering personnel are afraid a leak in a process heat exchanger may result in contamination of the condensate, so the condensate is sent to the drain. In many systems, leaks in condensate receivers or piping cause the loss of some or all the available condensate.

In our example boiler system, returning 25% of the condensate would provide a direct savings of 6 million BTUs per day as compared to returning none of the condensate. This equals $54/day, or $18,360/year. Returning all the condensate would directly save almost $75,000/year in fuel cost. In addition to the direct fuel savings, returning condensate would save a commensurate amount of make-up water, and, because the condensate is very low in dissolved solids content, less blowdown would be required, providing further savings in water, chemicals and energy.

Making changes to a boiler system to return more condensate, like most of the other energy-saving changes we have discussed, will likely cost money. Most changes provide a return on investment (ROI), but knowing what the ROI will actually be is necessary to assure the money is well-spent. Not being able to accurately determine how much money a system change will save reduces the engineering manager's planning process to guesswork.

One water treatment company has developed a program that takes the guesswork out of boiler system energy management planning. The program, called GPS, was developed by International Chemtex Corporation (Chemtex), a Lakeville, Minnesota provider of water treatment chemicals and services.

Lynn Shaw, Chemtex Technical Director, says that the GPS program enables engineers and facilities managers to track all the energy flows around their boiler system. Shaw says the program is easy for customers to use.

"We provide our customers a GPS log sheet, and they record the required data over time," Shaw said.

"When the data collection is complete, it's entered into our GPS computer program, which produces a printout showing all the energy inputs and outputs to and from the system, including all the areas of energy loss," he related. Shaw further explained that the losses are quantified in both BTUs and dollars, based on the customer's current fuel price. The initial printout serves as the "baseline."

"Then," he said, "the customer can use the program to simulate possible changes that could be made to the system to save energy. Subsequent program printouts show how much each change would save."

Shaw says this "what if" capability is invaluable to Chemtex customers. "They can see how much they'll save before they commit money to making a change. Most of our customer's budgets are really tight, and they can't afford to spend money they won't recover quickly."

In today's economy, tight budgets are the norm. The typical facilities manager may think he can't afford to spend money on operational changes to his boiler system. The Chemtex GPS program may show him he can't afford not to.

Take the guesswork out of boiler system energy planning.

Talk to your Chemtex Representative about the GPS Program today!